Geo Factsheet

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Hurricane Matthew October 2016

Introduction

When Hurricane Matthew became a Category 5 hurricane at 13.30N, it entered the record books as the strongest hurricane ever to be recorded at such a low latitude in the Atlantic Basin, surpassing Hurricane Ivan in 2004. It became known as the big, bad beast. It became the first Category 5 hurricane in this region since Felix hit Nicaragua in 2007, reaching sustained wind speeds of 160 miles per hour and a minimum low pressure of 934mb. Matthew was the strongest and longest lasting of the three major Atlantic hurricanes in 2016, along with Gaston (August) and Nicole (October). It lasted 8 days, from 30 September until 7 October, when it made landfall at South Carolina as a Category 1 hurricane and died out as it became consumed by a cold front.

Development of Hurricane Matthew

Matthew began as a tropical wave off the west coast of Africa on 22 September. Six days later, it was classed as a tropical storm as it approached St Lucia and then, as it passed across the Caribbean basin, it underwent explosive intensification. Wind speed doubled from 80 to 160 mph, meaning that it changed from Category 1 to Category 5 within 24 hours. Conditions that promoted this development were very warm surface waters and markedly weak vertical wind shear that is critical in the development of hurricanes. Wind shear is the difference in wind speed between 5,000 feet and 40,000 feet (the top of the troposphere), and absence of wind shear allows the vertical structure of a hurricane to remain very strong. An uncommon phenomenon known as lightning sprites occurred at the point of highest intensity near Puerto Rica. Sprites are large-scale electrical discharges that occur above cumulonimbus clouds, creating a variety of luminous orange-red flashes, caused by discharges of positive lightning between an underlying thundercloud and the ground. Matthew tracked westward off the northern coast of South America, but as it strengthened rapidly, it turned north making four landfalls in Haiti, Cuba, Bahamas and finally South Carolina, continuing for many days along the SE coast of USA (Figure 1), where storm surge, flooding and beach erosion occurred.

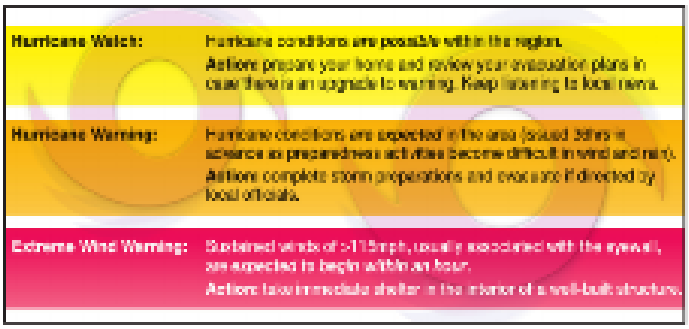
Figure 1. Track of Hurricane Matthew

Prior to the arrival of Matthew in the USA, there had been a slow-moving low pressure system that had saturated the region. As Matthew hit a frontal system, 500mm of rain fell over North Carolina, causing widespread flooding. This huge amount of rainfall was explained by the presence of cloud-top temperatures of -80°F at the centre of the circulation, creating very strong uplift and hence condensation and intense rainfall.

Regional Preparation for Matthew

Satellite monitoring meant that the region was notified of Matthew's approach, although many of the poorest populations were not aware of this information. Hurricane watches & warnings were issued:

Figure 2. Hurricane Alerts



The effectiveness of preparedness measures depended on the resources available and the quality of local and national governance. Common responses were the cancellation of flights, closure of schools and businesses, boarding of houses and stockpiling of supplies, and mass evacuations to emergency shelters. Table 1 shows how countries prepared for Matthew.

Preparations in Haiti

It was predicted that 380-640mm of rainfall would affect the whole country, with peaks of up to 1000mm on the Tiburon Peninsula, in the south-west of Haiti (Figure 3). A hurricane watch was upgraded to warning within hours and applied to the whole country, such was the scale and predicted track. The main concern was that although Haiti had some procedures in place, being so poor and still recovering from the 2010 earthquake that devastated Port-au-Prince, it did not have the capacity to cope with another large-scale natural disaster.

Figure 3. Impact of Matthew on Haiti

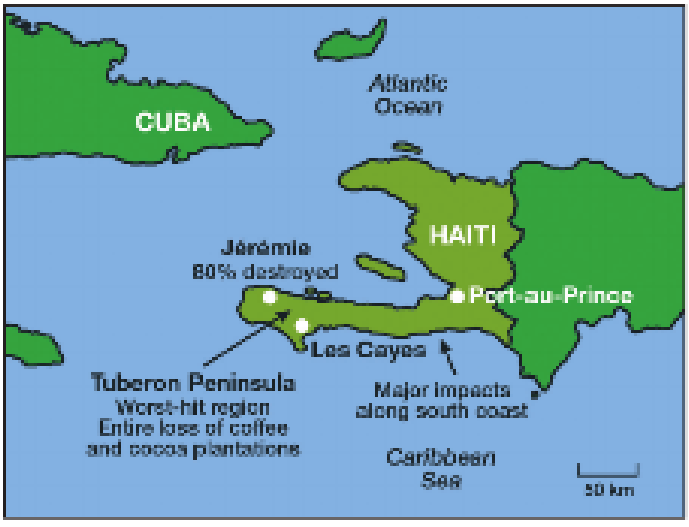


Table 1. Examples of countries' preparations for Matthew

Country	Measures of Preparation
Colombia	Homes boarded and supplies stockpiled. Peace Agreement Referendum was postponed (and its eventual rejection was blamed on low voter turnout due to post-Matthew conditions).
Cuba	>1 million evacuated. Medical staff sent to high risk zones. Supplies stockpiled. Schools closed. 218 shelters opened.
Dominican Republic	8,500 evacuated.
Jamaica	All fishermen called to return to mainland. Government put on high alert. 900 shelters opened and residents advised to buy supplies. Homes boarded and sand bags used. One hundred female prisoners were relocated to Kingston. Toll fees along Highway 2000 were waived during the hours before Matthew's arrival. Airport and public transport schedules suspended. The Jamaica Defence Force was deployed nationwide in advance of the hurricane in order to more swiftly deal with its aftermath. Schools and government offices were suspended. The National Arena was used for evacuation. Warnings that the infrastructure of Kingston would be unable to handle the magnitude of rainfall expected.
St Lucia	Underprepared as there was no expectation of being impacted. Flights were cancelled and schools closed.
USA	Several states issued States of Emergency.

Haiti only had schools for shelters to protect 390,000 people, far short of the number of people threatened by Matthew. The National Emergency Operations Centre was activated, shipping was ordered to port (although many local fishermen continued to work) and evacuation notices were issued. Despite the work of civil protection officers visiting neighbourhoods, it was reported that many people were unaware of the impending arrival of Matthew, or refused to leave their homes. Those with secure homes were asked to house vulnerable neighbours. Hospital patients and some prisoners were relocated to safer areas. Ahead of the storm, 18,000 volunteers, Red Cross members, local government officials, and medical teams were dispatched to the most vulnerable areas. There was also a pre-disaster response from the international community, with teams from the UN Disaster and Assessment Coordination and USAID put in place.

Impact of Matthew on Haiti

Matthew made landfall on Haiti as a Category 4 hurricane. There was widespread flooding, with coastal settlements affected by a storm surge of 3m. Trees, buildings, and telecommunications were brought down. This, together with collapsed bridges, meant that large populations were isolated and rescue efforts were delayed for days afterwards. In total, approximately 2.1 million people were affected, leaving 12% of the national population in need of assistance afterwards, of which 40% were children and 40% were women of reproductive age. Nationally, 175,000 were made homeless by Matthew, and children became separated from their parents in the chaos. This compares with 1.1 million who at the time of Matthew were still homeless as a result of the earthquake in 2010. Whilst figures vary, it is thought that up to 1600 people died in Haiti, and damages amounted to £1.89 billion. Many deaths were the result of people who refused to leave their homes and were subsequently buried by rubble as the houses collapsed.

Nationwide, the hurricane severely damaged about 200,000 homes, with 90% of the houses along the southern coast destroyed. 400 damaged schools affected 130,000 children and hospitals and health clinics were not only damaged but became short-staffed as patients increased. Rice prices soared immediately after Matthew, leaving the poorest unable to buy food. It was estimated that 800,000 people faced critical food shortages three weeks after the event. The general election had to be postponed as polling stations were damaged and people could not get to them.

An unintended consequence of the 2010 earthquake was the introduction of cholera to the country, by UN peacekeeping forces. Matthew destroyed 34 cholera treatment centres, creating a crisis in the following week as more than 1300 people became infected through dirty drinking water, and 29 deaths were reported. Medical supplies ran very low as roads were blocked. The WHO sent 1 million anti-cholera vaccines to Haiti and the UN donated $8 million to UNICEF for their work in controlling the spread of disease.

The worst-affected region was the Tiburon Peninsula (Figure 3), with the town of Jérémie virtually flattened, with 80% of the infrastructure and housing severely damaged by Hurricane Matthew. It took four days for the first humanitarian aid to arrive. In Tuberon, 90% of coconut trees, and entire coffee and cocoa plantations were destroyed. Other crops were ruined and 350,000 livestock killed, leaving Haiti's southern population without food. 80% of Tiburon lost power and communications. Road access to Port-au-Prince was impossible due to flooding and mudslides washing away bridges, so humanitarian relief had to be airlifted in.

Haiti's Response to Matthew

As Haiti (an LDC) is the poorest country in the western hemisphere, struggling with extremely low GDP and poor governance, it requested international aid. An emergency appeal was launched by the UN for $120 million and within ten days, $40.1 million had been pledged. Dominica and Bahamas both gave $100,000, Venezuela sent two ships with 20 tons of supplies, and Canada donated C$6 million towards securing drinking water supplies. UN peacekeeping forces already in the country had their mission extended for six months and were immediately employed to clear roads. The World Food Programme (WFP) and NGOs distributed 1500 tons of food and those still in temporary camps from the earthquake six years earlier received emergency kits containing food, blankets and medicines. Some of the many who lost their livelihoods were temporarily employed clearing debris in their villages. Other contributions are shown in Table 2.

Table 2. International donors to Haiti's disaster management

Donor	Monetary	Resources
Australia	A$3.5 million	Donation to UNICEF and International Organisation for Migration
Estonia	€50,000	-
European Union	€1.75 million	-
France	-	Two reconnaissance helicopters, water purification equipment
Ireland	€1.7 million	-
Luxembourg Red Cross	-	Team of disaster experts
Netherlands	-	Two ships
Singapore Red Cross	US$30,000	Medicine and water
Spanish Red Cross	-	5 tons of supplies
South Korea	US$350,000	-
Switzerland	-	Experts in shelter-building, security, water restoration
UK	£8 million	Temporary shelters, water purification equipment, cholera prevention
USA	US$38 million	3 ships (one a hospital ship), 480 tons of supplies

Despite Haiti's poverty and limited capacity to cope with natural disasters, there were positive outcomes, achieved by working in partnership with agencies. Around a fortnight after being hit, Haiti had restored most of the telecommunications and road network.

Impacts on Other Affected Countries

Matthew impacted heavily on several Caribbean countries and ranks 10th in the all-time list of costly Atlantic hurricanes (Table 3). For example, it was Cuba's second most costly hurricane, after Ike in 2008. The Bahamas took a direct hit from the eyewall and suffered extensive wind and flood damage, amounting to US$600 million. But it was the USA's eastern seaboard that experienced the severest impacts, despite the preparedness measures of a richly resourced country. States of emergency had been issued in Florida and North Carolina on October 3rd. A day later, everyone living within 100 miles of the coast of South Carolina had been advised to evacuate; this was upgraded to mandatory evacuation on the 5th October. The Interstate 26 was reversed to allow both carriageways to take traffic away from the risk zone. Port Canaveral was closed for the first time in 12 years, affecting cruise and cargo ships. Also shut down for one day was Disney World resort, along with other Orlando theme parks. The Kennedy Space Centre suspended planned launches of satellites. By October 6th, Georgia had a state of emergency and took similar measures to neighbouring states. Despite these preparations, and that Matthew rapidly downgraded to Category 2 off the Florida coast, 49 deaths were recorded, mostly in North Carolina and Florida.

Figure 4. Timeline of Matthew's Impact on Haiti

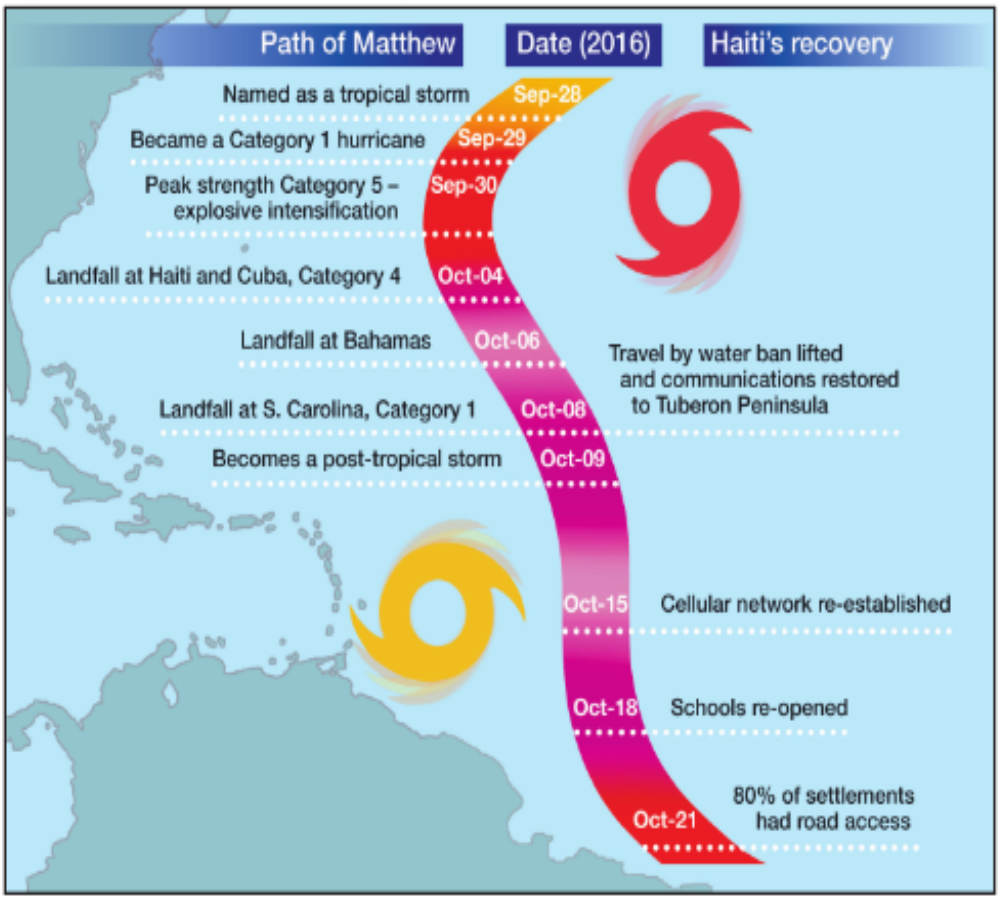


Table 3. Top 10 costliest Atlantic hurricanes

Hurricane	Year	Damage (US$ billion)
Katrina	2005	108.0
Sandy	2012	75.0
Ike	2008	37.5
Wilma	2005	29.4
Andrew	1992	26.5
Ivan	2004	23.3
Irene	2011	16.6
Charley	2004	16.3
Rita	2005	12.0
Matthew	2016	10.6

Hurricane Matthew was the greatest loss of life since Hurricane Floyd hit North Carolina in 1999. Economic losses were estimated at US$4-6 billion. Due to the heavily populated coastline, millions of people were affected by loss of power and blocked roads. Extensive sand dune erosion and breached sea walls allowed coastal flooding, and inland, raised rivers caused extensive damage and was responsible for most deaths.

Future Category 6 Hurricanes?

As Hurricane Matthew was possibly the furthest south ever recorded in the Atlantic Basin, within the context of global warming, are hurricanes going to get stronger and does the Saffir-Simpson scale need to be extended to accommodate this? Currently, scientists are looking to add value to the Saffir-Simpson scale by including other aspects, such as wave height, storm surge, and flood risks. This is difficult because they can vary spatially within any hurricane, but potentially are more useful. Scientists have run different climate models and results show that three areas in particular – Tampa, Florida; Cairns, Australia and the Persian Gulf – will be particularly vulnerable to Category 6 hurricanes by the end of the century. They may be 14 times more likely, with wind speeds possibly up to 233mph and a minimum central pressure of 830mb, producing a storm surge of 36 feet.

The Future for Haiti

Haiti has one of the highest exposures to multiple hazards, with the 5th highest mortality risk. 96% of its population is at risk and is the most vulnerable of the small island states in the Caribbean to both earthquakes and the effects of hurricanes. This, combined with high levels of poverty, ineffective governance and weak public infrastructure, creates high vulnerability. The implications of climate change for Haiti underlines the need for a proactive approach to disaster risk reduction. An early warning system, effective use of its meteorological data and control of deforestation, caused by charcoal production, is essential to reduce risk of flooding and landslides. The frequency with which hurricanes hit Haiti means that it is in a vicious circle of poverty, violence, socioeconomic political instability, and poor infrastructure. It is hard to see how the country can achieve sustainable development without substantial and prolonged input of expertise and funding from outside agencies.

Further Research

These sources either record the devastation during the storm or immediately post the disaster. Check again every sixth months to assess the progress:

www.unicef.org.uk/hurricane-matthew-haiti (one of many NGO sites)
https://weather.com/storms/hurricane/news (provides storm updates)
www.ibtimes.co.uk (records effects of Matthew on Haiti on video)
http://www.nhc.noaa.gov/